Teaching nature of physics in French high schools

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keywords : *teaching, NOS, physics, video analysis*

1. Rationale of the research

Research conducted for several decades in several countries on students' conceptions about the nature of science (NOS) shows steadily that, no matter their science curriculum, students have an inconsistent understanding on the nature of science (Desautels & Larochelle, 1989; Lederman, 1992).

Those findings justify the research on NOS teaching within institutional recommendations developed in foreign contexts particularly in USA. Actually, different standards (NSES, 1996, BSL, 1993) provide a place for NOS in the curriculum as teaching content from kindergarten to high school. According to the research results:

- NOS knowledge is transmitted by means, both explicit and contextualized to scientific knowledge (Ryder & Leach, 2008). It is also implicitly conveyed in the teacher’s ordinary language in the presentation of subject matter and implemented in activities that provide context in which students understand items related to the nature of knowledge (Brickhouse, 1990; Zeidler & Lederman, 1989).
- Teachers act from their personal and implicit system of knowledge and beliefs that includes views on the NOS, views on science teaching and views on the learning process. These three components are strongly nested especially in the teaching methods used by experienced teachers (Tsai, 2002); this interrelation grows with practice (Brickhouse, 1990). These nested epistemologies have an influence on teaching practices and vice versa (Nott & Wellington, 1996). Water-Adams (2006) even finds that the latter has a greater on the former.

These conclusions, although deducted from various studies, serve as a base to question more precisely the situation of Physics teaching in France. The French and US educational context about NOS teaching are different: according French curricula science teachers have to teach students how science proceeds. This issue is strongly related to the student’s scientific literacy, critically thought and use of inquiry based methods as practices. However, curricula keep NOS at a general level and do not allow teachers to clearly identify goals of such teaching and therefore assessment and teaching methods, moreover teachers’ lack of knowledge of NOS and transmission of NOS. Thus, although the overall intentions are asserted, it is not sure that in practice, science teaching takes into account these aspects and induces the expected response: from the teacher’s standpoint, scientific practices at school and scientific practices in laboratories are scarcely connected (Richoux and Beaufils, 2002).

The foreign research findings about NOS teaching and the specificities of the educational French context about NOS lead us to study the transmission of NOS knowledge in France by analyzing physics teaching when teachers choose to teach NOS, even it is not explicitly stipulated in the curricula. We have addressed this problem by adopting the following two assumptions based on research findings:

- there are factors related to tasks and teaching contexts that lead teachers to build, through the teaching of physics, personal views on the NOS;
- NOS teaching practices, identifiable through the teachers’ words and actions during class, are based on nested teachers’ beliefs on teaching science, learning science and nature of science.

2. Theoretical framework and methodology

Research on NOS, already mentioned in the previous section constitutes the first part of our theoretical framework. It leads us to study teachers' practices that refer to NOS. In order to analyse these practices, we rely on NOS theory (Bunge, 2001) to build descriptors about what a model is, a law and a theory in physics are, what are their characteristics, what hypothesis and experiment in physics are and what are the relations between them, their relations with theory, etc.

We use this epistemological framework to examine two physics lessons developed in grade 10 by two different teachers. The first teacher (A) approach NOS on his own ; the lesson we observe is one of the small number of cases in which he wants to teach NOS and he designs this lesson alone. The other (B) works on model and modeling in physics and chemistry teaching with a research team in didactics.

Because the French physics curriculum does not mention NOS topics we study physics lessons in which NOS topics are selected by the teachers themselves while they teach physics topics. The lessons we observed deal with gas properties and the use of the microscopic model of gas to interpret Boyle-Mariotte's law. In this case, we think that NOS is involved in a explicit or an implicit way in what it is worked in class, particulary in the verbal interactions between students and teachers.

We try to identify and describe teaching of NOS knowledge 1) by analysing talk of the teacher and teacher and students' interactions about scientific topics during class; 2) by analysing what it is worked in relation to NOS Thus, video data of the lesson constitute the main corpus. The Transana software is used to transcribe the lesson. Then, the video is cut into episodes indexed with keywords originating from NOS theory. The Transana outputs provide: 1) a global, static view of the lesson based on the number of episodes related to each keyword; 2) a global, dynamic view of the lesson based on the distribution of keywords over time. The previous analysis is triangulated with elements of the auxiliary corpuses (interviews before and after the lesson, curriculum documents about the knowledge taught, students' work, etc.). It makes us to know : 1) the kind of NOS knowledge taught in class ; 2) the kind of references that play a role in teaching NOS ; 3) the factors underlying the choices made by the teachers in terms of NOS content and teaching methods ; 4) the role played by their views on NOS, teaching and learning physics in high school. Examples will show the use of the different descriptors in this analysis.

3. Findings and discussion

There are many differences between the two lessons: for the first one, the interactions between the teacher A and his students are about scientific knowledge only. The NOS taught knowledge is related to models but always implicit and probably difficult to be learned by the students; this is probably strengthened by the rarity of NOS teaching lessons. Students are not expected to identify clearly what a model is, what characterizes it and how to use it. We identify that the teacher's view on NOS is related at his views on physics teaching and learning. However, he is able to distinguish scientific school practices from science practice in laboratories.

During the other lesson, NOS knowledge is taught through specific and explicit words about model and modeling. These knowledge is embedded in physics contents. The teacher B often talks about scientific model at the same time he talks about gas properties and model: how to improve the model, how to valid it with experiments, how to use it to explain an event. He uses a NOS model that distinguishes the world of theories and models from the world of objects and events (Tiberghien, 1994). Students have to base on it to distinguish these two aspects occurring in talks about gas. At the end of the lesson, they have to use it to draw a posteriori the way they have followed going back and forth between these two worlds. Model and modeling are regularly used by this teacher B in order to teach physics contents. He has a contemporary view on NOS; however, his talk about it is embedded in the previous two worlds model.

These findings bring us to discuss some points with regard to the purpose of the symposium:

As it was already mentioned by Lederman (1999), teaching NOS for the teacher A is one factor among many others (timing, class context, students abilities...) to be taken into account as a constraint in teaching practice. It is perhaps because this teacher is alone to design the lessons about NOS. In this context, it is not surprising to see that teaching scientific knowledge has an influence on NOS understanding and NOS teaching views (Brickhouse, 1990, Walter-Adams, 2006).

But this interpretation does not work for the second teacher B: NOS teaching is not the main knowledge to teach, but an integral part of his teaching program. Thus, his NOS teaching is not limited by the necessity to take into account the other classic factors which constraints teaching practices. According to the anthropological theory of didactics (Chevallard, 1992), all activities of a person who has a position in an institution are shaped within the task system of the institution. In the case of the second teacher, his practice of NOS teaching refers less to his relation at « physics teaching practice in a high school » than to his relation to his research group.

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